Doe

Relation between Leading and the Legibility of the Printed Page

RELATION BETWEEN LEADING AND THE LEGIBILITY OF THE PRINTED PAGE

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Arts in Psychology

Madison Bentley

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I. Introduction

The aim of the study here reported was to determine whether there is a noticeable degree of dependence of the legibility of the ordinary printed page upon the space which the printer leaves between successive lines. This interlinear space is technically known as "leading." The recent investigation by Roethlein[1] on the relation obtaining between legibility and the characteristics of the type-face has made it appear that both the face and the style of the type affect the rate and ease of reading printed characters and words. This study has also made evident the varying legibility of the different letters within the alphabet of a single type-face. Still other factors of the same order which facilitate or retard reading are the form and the size of the letter, the position of the single letter in the letter-group, size and shape of adjacent letters, and the width of the white margin left about letter and word. It was this last factor of margin which suggested our own problem. Instead of the whole matter of the margin, however, our study has been limited to the relation which obtains between the interlinear spacing, the "leading," and the legibility of the page.

As far as can be determined, very little work has been done on just such a problem, although upon related subjects we find some material. Rapeer gives in his book on Education Hygiene[2]

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[1] Roethlein, B.E., Legibility of different faces of printing types, Amer. J. of Psychol., 1912, xxiii, 1-36.

[2] Rapeer, L.W., Education hygiene, New York, 1915, p.589.

the recommendations of the committee of the American School Hygiene Association for minimal standards for type, spacing, and leading in the earlier school years. Just how these standards were determined is not mentioned. With the first grade, the height of small letters should be 2.6 mm. and the leading should be from 4 to 4.5 mm. For the fourthyear, height and leading should not be less than 1.6 mm. and 3 mm. respectively. Huey, who has done much work on the psychology of reading, sums up in a late work the results of those who have contributed data concerning hygienic requirements and the printing of books and papers.[3] H. Cohn's work on the thickness of the vertical stroke of letters shows .25 mm. as the minimal thickness, while Sack shows the minimal thickness to be .3 mm. It is found by most investigators that .3 mm. is the minimal distance that should be found in the space between the vertical lines of letters. Cohn and Sack agree on 2.5 mm. as a minimal leading. Experiments by Griffing and Franz show that fatigue increases rapidly as the size of the type decreases. They have also done some work on the relation between illumination and size of type. From their experiments on legibility and leading they found that legibility increased, though not greatly, with increase in distance between lines. E. Javal, on the other hand, does not find legibility increased with spacing between lines. He believes the spacing can be neglected and larger type used with better results. W.F.Dearborn and E.B.Huey have experimented in problems of eye-movement. Others have taken up such work as the optimal length of line, quality and color of paper, and various related subjects. Very little, if any, of the work, however,

[3] Huey,E.G.,The psychology and pedagogy of reading,New York, 1912,p.406.

touches this problem directly. That which does seems, too, to present results quite arbitrarily, with no description of the method by which they were obtained.

II. The Experiments

(a) Materials and Apparatus. The materials used in the present experiment were white unglossed cards, $7\frac{1}{2}$ x $6\frac{1}{2}$ in., in the center of which were printed blocks of reading-matter on various subjects gathered from books, magazines, and papers. The primary object in selecting our reading matter was to secure material fairly uniform with respect to ease of apprehension.

The type used was 12-point "Monotype,"[4] a near approximation to "News Gothic," which was the optimal type-face determined by the Roethlein experiments. This large type was decided upon in order that the printed matter might be presented at considerable distances thus insuring varying degrees of difficulty in reading. It was used in the first two of the three distances chosen for presenting the cards. For the third, or nearest, distance, photographic reduction of the 12-point printed texts was obtained. This reduction made the type approximate 6-point type in size as measured from the printed letters.

The text blocked in the center of each card was always exactly ten lines long. The length of the lines was determined from averages of line-lengths in common use to-day. It was 3 3/8 in.

The printed cards used were of different leadings. There were nine each for leadings 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. This made a total of ninety cards, which constituted a series. Each card had printed on it a different subject-matter. Leading "0"

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[4] Specially set up and printed by Messrs. R. R. Donnelley and Sons Company of Chicago, whose aid and cooperation the writer begs to acknowledge.

was "set solid." As printers use the term, "set solid" refers to type set with no spacing strips or leads between the lines, that is to say that the lines are set as closely together as possible. However, in the page printed from type "set solid" there is a space between the lines, hence 0-leading does not indicate entire absence of spacing between lines. This is due to the fact that the base of the type extends beyond its face both above and below, in order to support the "risers" and "descenders," -- the extensions found on such letters as <u>h</u>, <u>l</u>, <u>f</u> and <u>g</u>. From 0-points the distances between lines increase gradually until at 9-points we have our maximal spacing of the lines. With each additional point the distance between lines increases approximately 1/72-inch.

The cards upon which the reading-matter was printed were presented to the observer in a frame 12 x 9 in. with a glass front the size of the cards and a hinged back for allowing the cards to be placed in position. This frame had before it a slide shutter rapidly passing downward when released to expose the card. At the top of the frame was a shaded incandescent lamp which gave a bright illumination to the card presented. By an arrangement of mirrors the distribution of light was made uniform over all portions of the card. The frame was borne by a carriage set upon an optical bench, which had upon it a centimeter scale for recording the presentation-distance as measured from the cornea of the eye to the printed card within the frame.

The whole apparatus was placed upon a long table. It was enclosed by a long wire frame-work over which was hung a black cloth cover. This formed a long closed space arranged for

the purpose of excluding from the field of vision the experimenter and objects that might tend to distract the observer from his reading.

The observer sat at one end of this closed space supporting his head in an adjustable head-rest. He fixated a white pointer which was adjusted at each reading to indicate the initial point of the reading-matter. This changed slightly each time because of the various leadings which changed the distance between the first and last lines on the card.

An electrically connected stop-watch and reaction-key were also used for the recording of the reading times.

(b) Methods of Procedure. The readings were all carried on in a partially darkened room so that the artificial illumination of the reading field might be kept constant throughout. The instructions given to the observers were as follows:

> "At a signal 'ready',you will be shown a grey expositive field; fixate the white pointer. At a second signal 'now', the grey field will be removed disclosing a block of printed-matter. Begin immediately to read aloud and at the same time press the key at your right hand. Read as clearly and as rapidly as you can. Do not correct errors. If a strange or an unclear word appears say 'blank' and continue reading. As you read the last word press the key a second time. After the reading report the number of mistakes made."

The experimenter had duplicate copies of the cards presented, and as the reading proceeded he recorded the mistakes, noting the character of each and, wherever possible, the particular circumstances which entered in. These 'objective' records of mistakes were additional factors in interpreting the results, in that they helped to explain extreme variations from the average reading-times of texts with like leading. The kinds of mistake

recorded consisted, in the main, of blanks, hesitations, wrong words or misreadings, disturbances of vocal mechanism, insertions, omissions and corrections which the observer at times automatically made contrary to the instructions given. As mentioned above, the presentation-distances were three. The first distance from which the cards were presented was 136 cm. This distance was chosen because it was a mean reading distance for 12-point print. The second distance was 176 cm. This distance, for the average person of emmetropic vision, was near the maximal reading distance for this type. Had presentation been given at a greater distance than 176 cm., the difficulty of reading would have introduced so great a number of mistakes that the results would have been equivocal. For the third distance, it was decided to reduce the size of the 12-point type and to present it at closer range. The cards containing the printed matter were photographically reproduced and in the resulting reduction the type was -- as we have explained -- equivalent to ordinary 6-point type. The third distance chosen was 88 cm. This was the fourth term of a proportion made up from the type sizes and the long presentation-distance as the other terms.

From each distance two series, each including the total number of 90 cards all of which bore different reading-matter, were presented to each observer. The order of presentation in each series of 90 was different, being determined by chance.

Observation periods were in most cases the same hours each day for each observer, 8:00 - 10:00 a.m. and 1:00 - 4:00 p.m. For the most part, uniformity in periods between observations was observed.

The observer was seated at the end of the table looking through the covered shute at the frame which concealed the printed card. At a signal 'ready', he was required to fixate the adjustable pointer which indicated the point at which the reading matter began. At a second signal 'now', the shutter was dropped down exposing the printed card. In accordance with the instructions, the observer immediately began reading, at the same time releasing the stop-watch by means of an electric key. With the last word, he stopped the watch by a second pressure upon the key. This automatically recorded the total time of reading for the card.

(c) Observers. The observers were instructors and students of psychology.[5] Only two of the observers served for all three distances. These gave six series of 90 readings each, making an individual total of 540 readings or a sum total of 1080 readings for all. The other three observers took part in the experiment for distances 136 cm. and 176 cm. They gave four series of 90 readings each, making an individual total of 360 readings or a sum total of 1080 readings. The total number of readings for the entire experiment was 2160. The readings, grouped to show the number for each distance, are as follows: 136 cm. -- 900 readings; 176 cm. -- 900 readings; 88cm. -- 360 readings.

(d) Results. The factors considered in the results were reading times, the number and character of objectively noted mistakes, the observer's reports of his mistakes for each reading, introspective reports taken from time to time, and various notes and comments upon the readings which the experimenter made throughout

[5] They were Dr.C.Rahn(R), Dr.R.C.Bentley(B), Mr.C.Griffith(G), and Misses D.Cuthbert(C), and A. Fluke(F).

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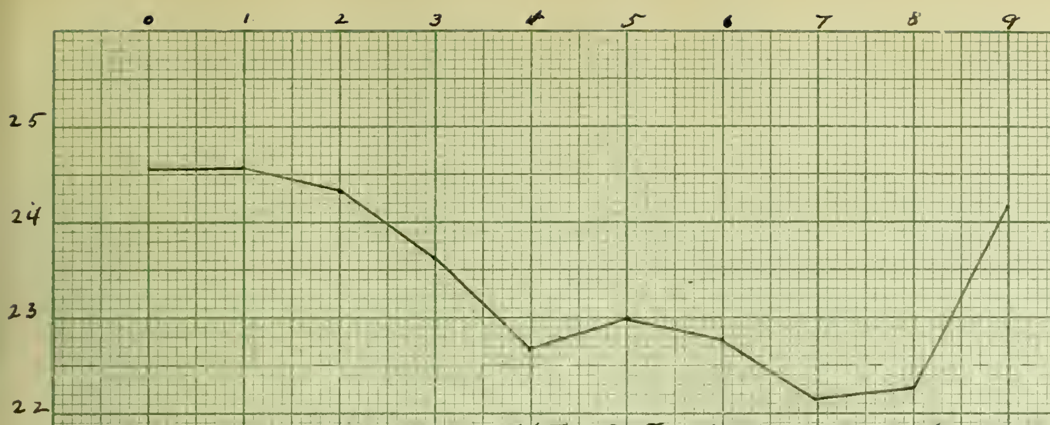

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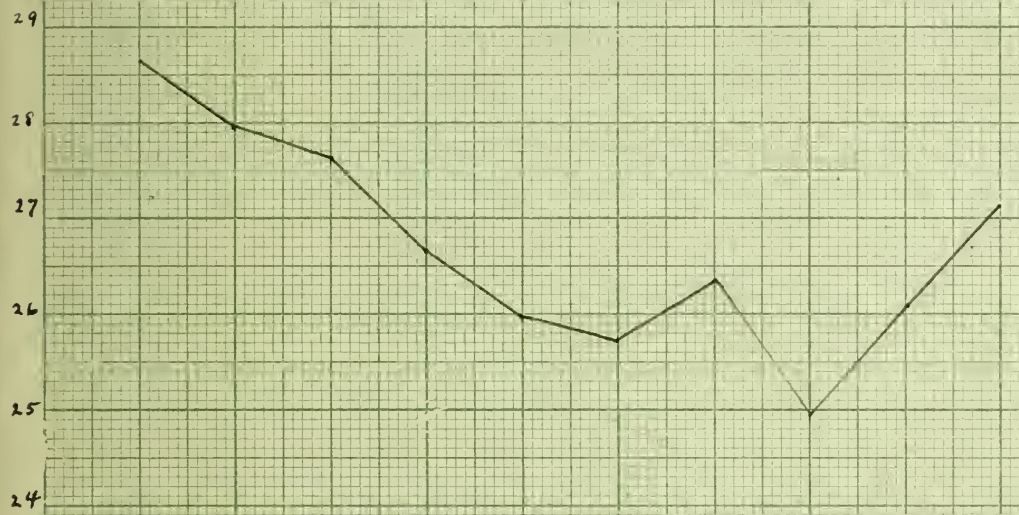

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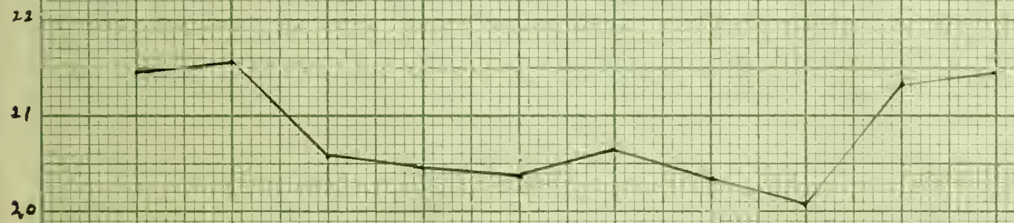

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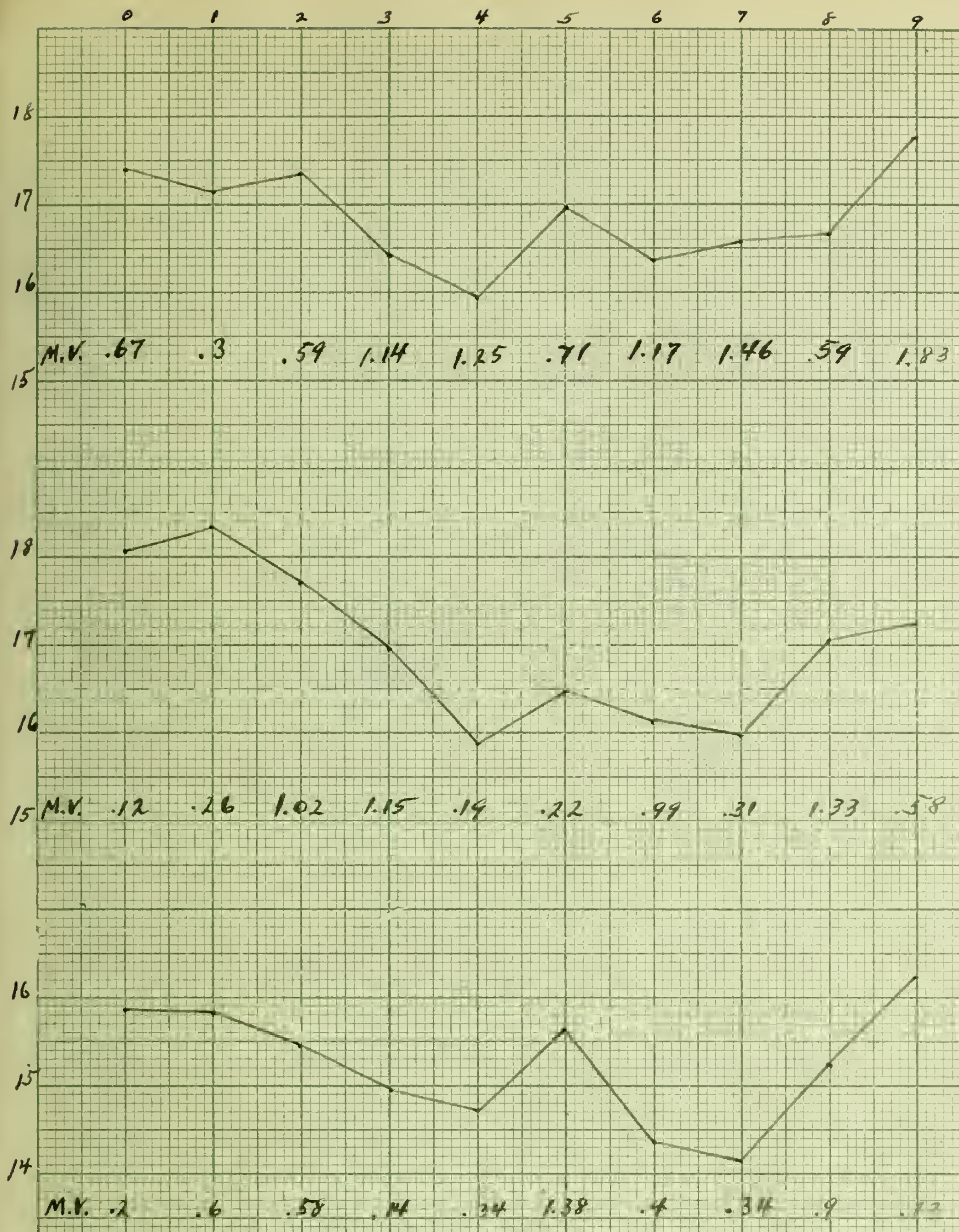
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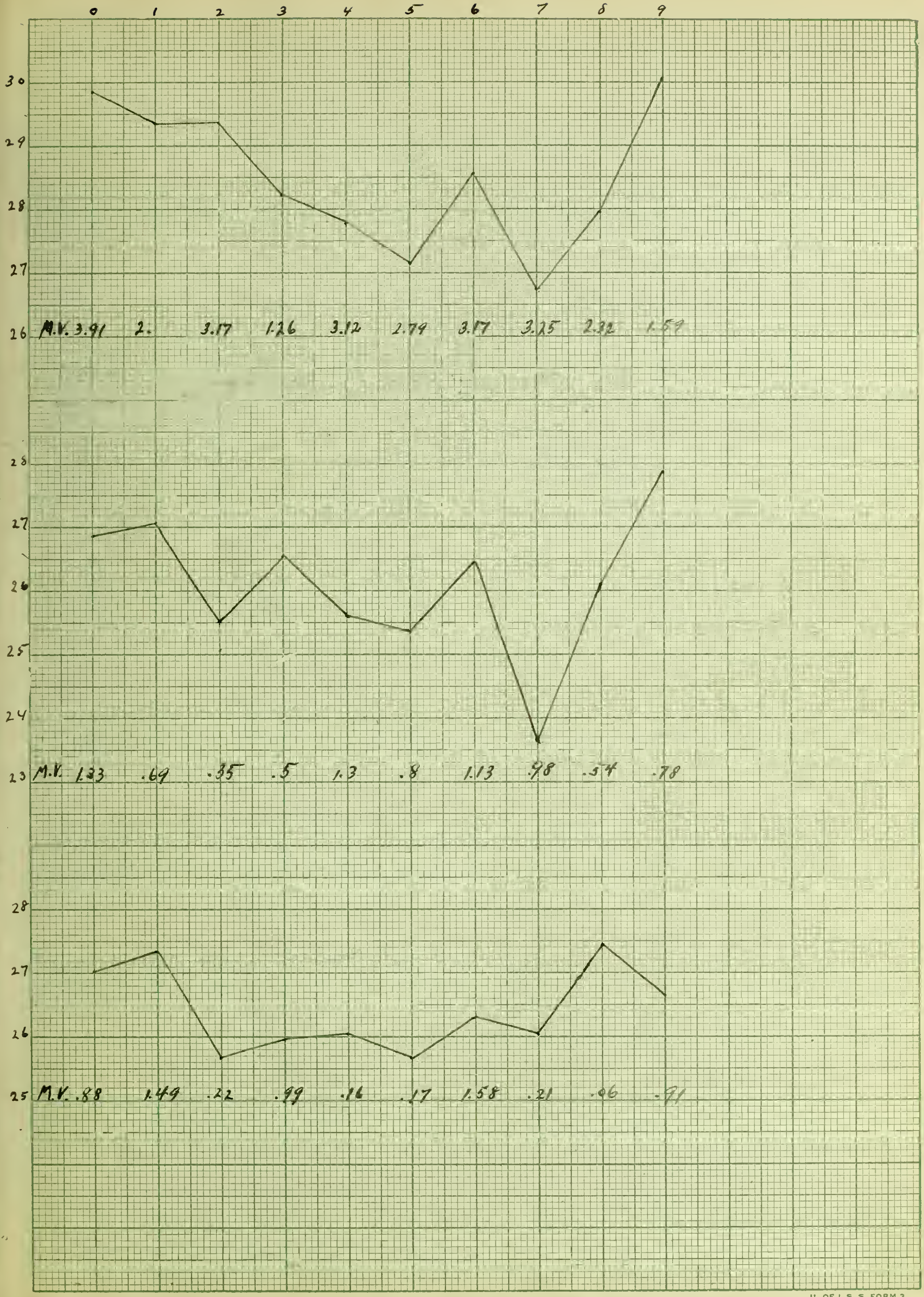
C.



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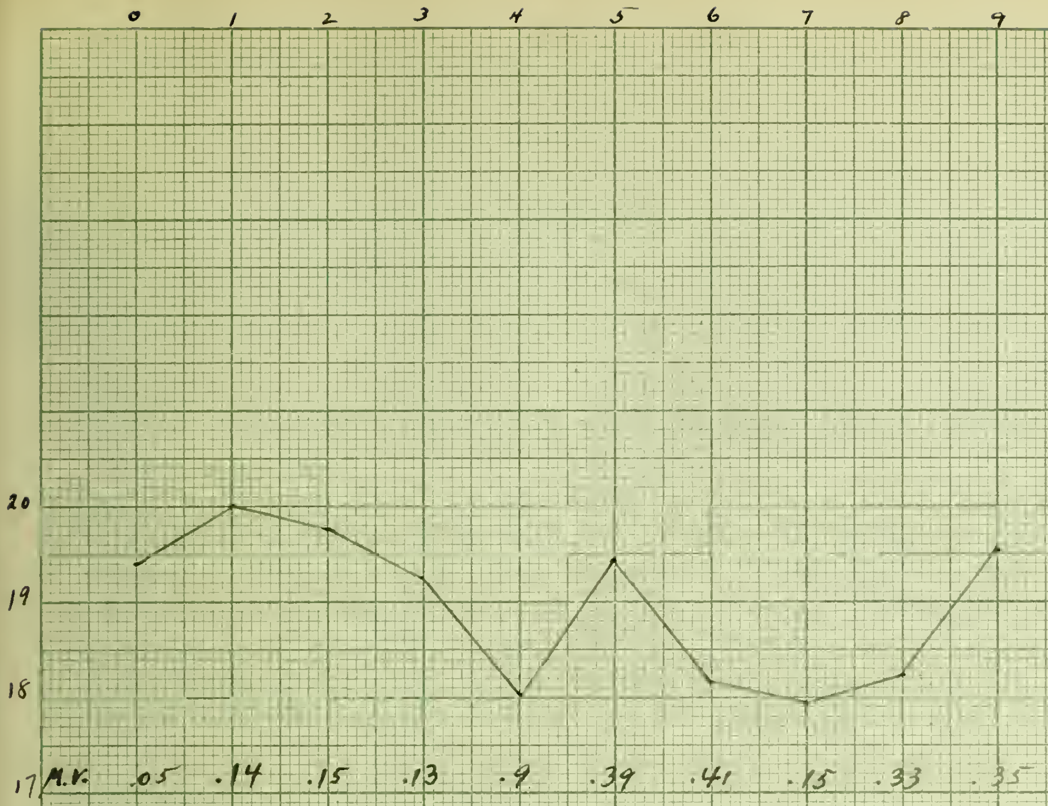
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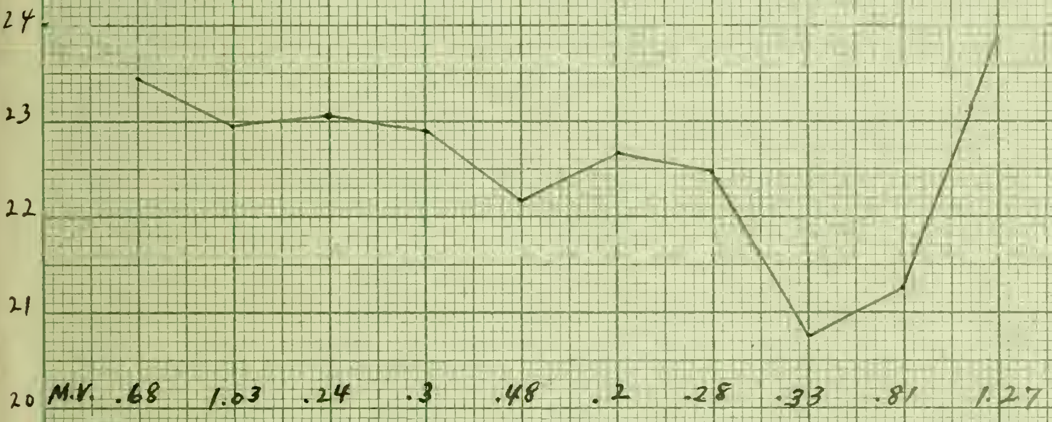
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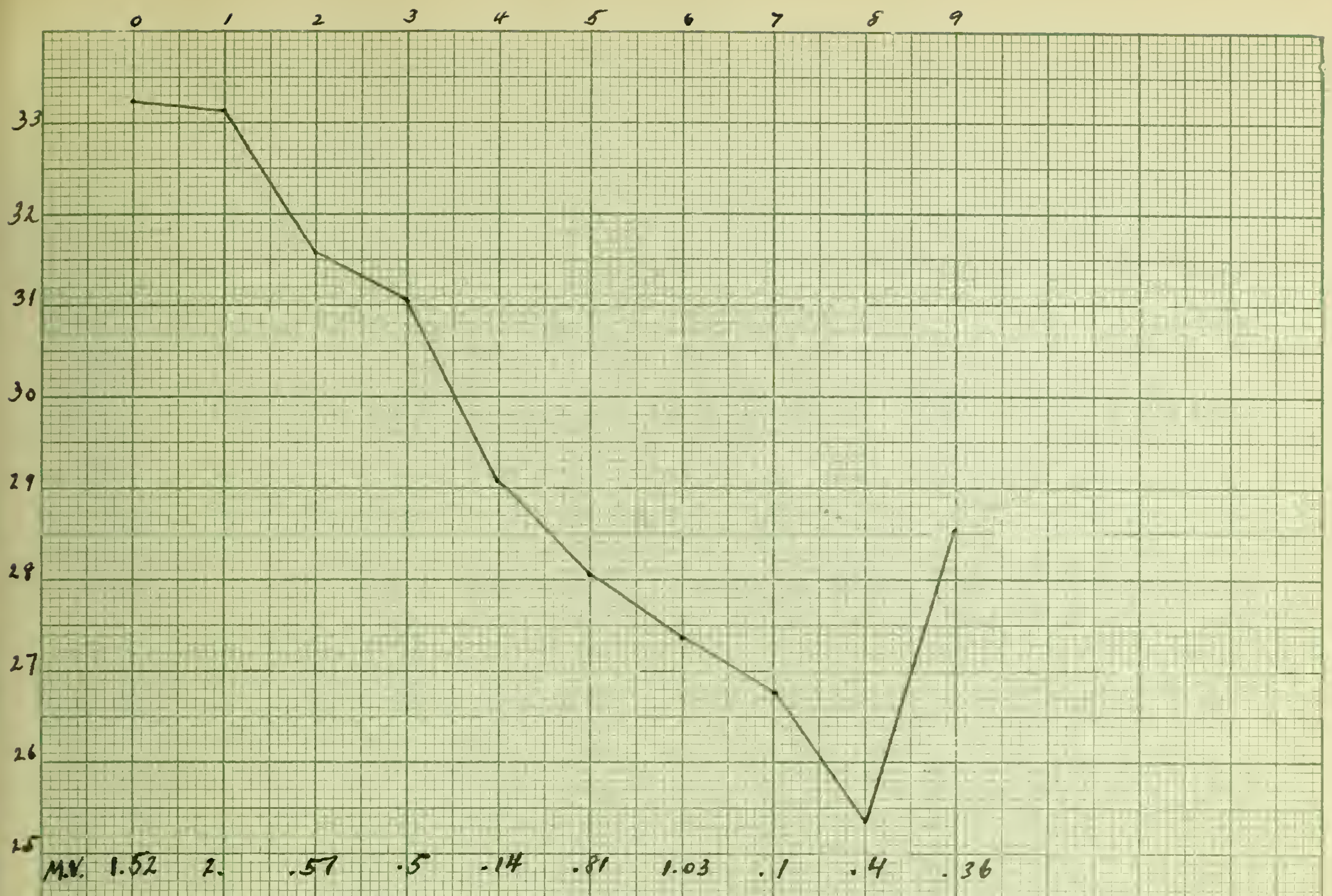
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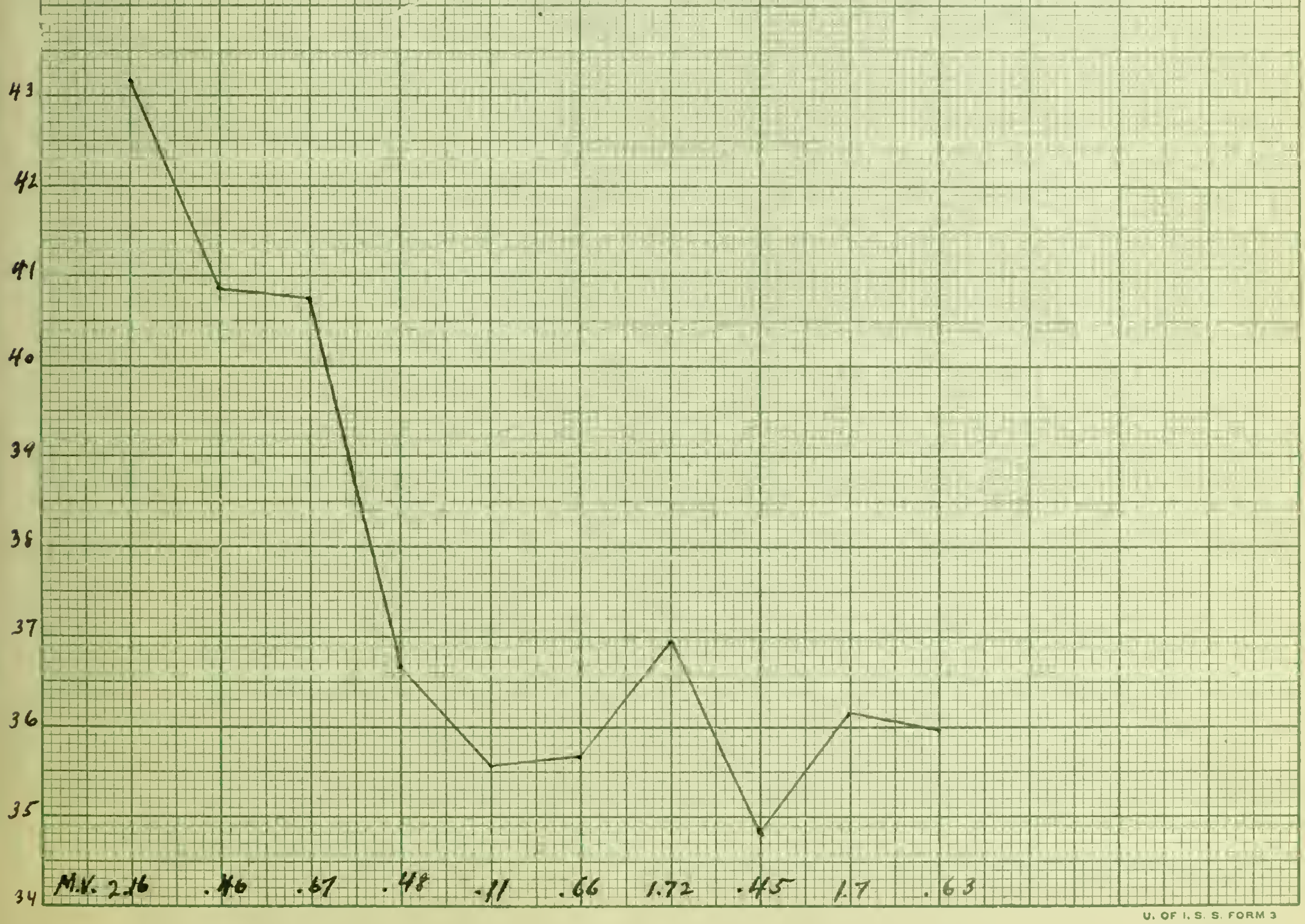
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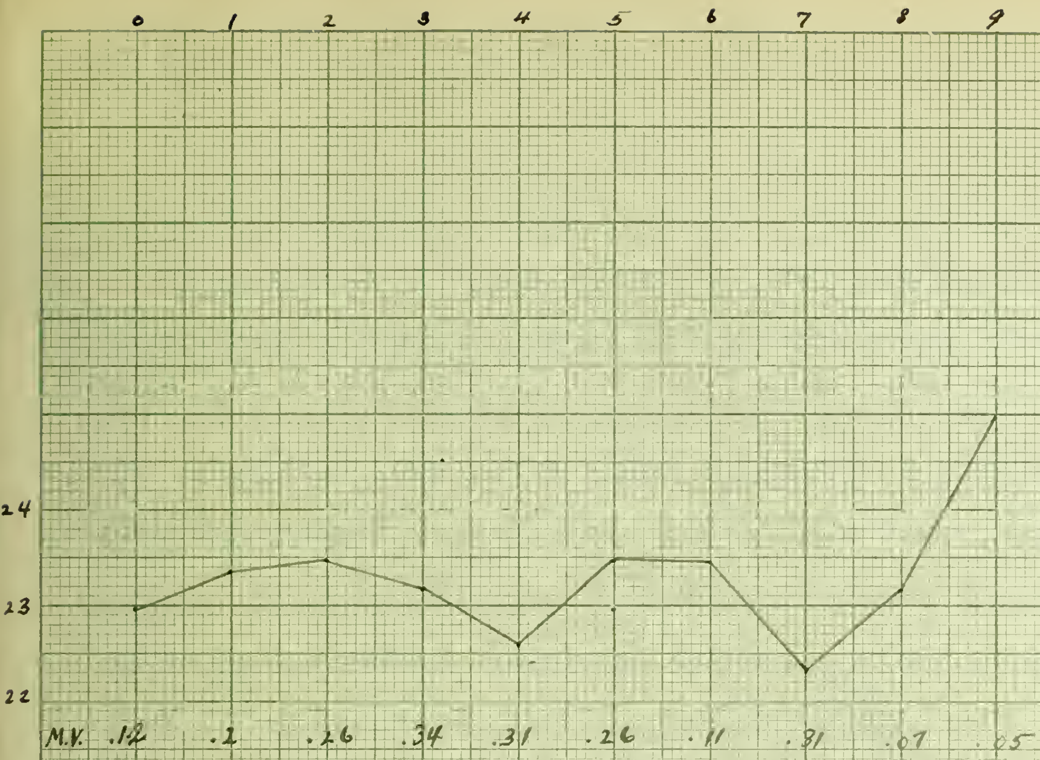
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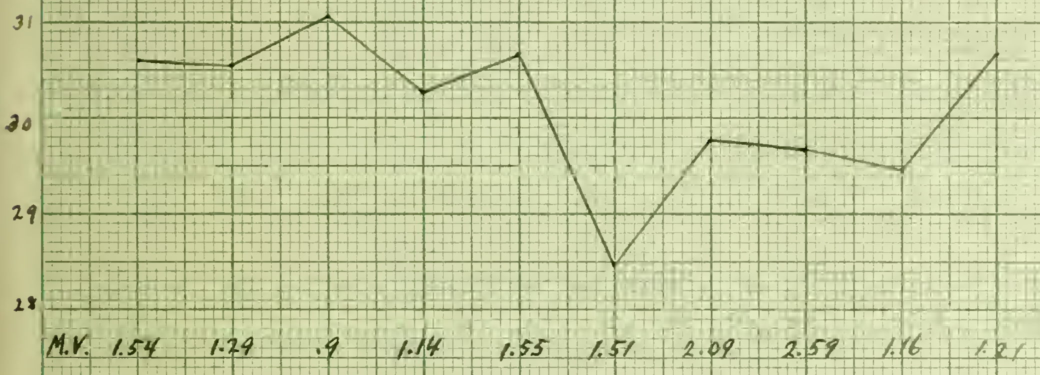
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the experiment. In the light of these facts the average reading-time for similarly leaded texts ,the mean variations, and the average number of mistakes made, were computed for each observer at a given distance. In addition, the total averages and mean variations were computed for all similarly leaded texts presented to all observers at a given distance. From these figures were constructed graphs for the individuals taken singly and collectively. In these graphs, as here presented, the initials represent the different observers and the letters A, B, and C indicate respectively the reading distances 136 cm., 176 cm., and 88 cm. The'total' graphs, made up from all the data collected at a given distance, are numbered I, II, and III to accord with these same distances.

On these graphs the reading time is represented in seconds upon the ordinate and the leading, in points, along the line of abscissas. The mean variation from the average time is given in each case just below the graph.

The graphs I, II, and III show, upon examination, a marked similarity throughout, although the usual variations are also to be seen. On the whole, they show a marked decrease in reading times with an increase of leading until a certain point is reached. At this point, further increase in leading brings about a rapid rise in the reading-times. The minor fluctuations in these curves are readily understood when they are considered in the light of the various factors which underlie the individual reading-times. The principal factors are as follows:

1. Objective factors, such as distractions, noise, etc.

2. Mental factors, such as associated images and slight emotions.

3. Bodily factors, such as ocular disturbances.

These all tended to increase the reading times and it is important to note that nearly all the extreme variations were variations of increased times. In a few cases where these extreme variations were of decreased times it was difficult to say just what conditions are responsible.

The most frequent and most important objective factor was noise. Aside from this another factor was the flickering of the electric light which illuminated the card presented. Of this, however, there were very few cases.

For the most part the mental factors came out in the introspections. Occasionally, however, these were indicated by a nervous laughter which obviously delayed the reading. An example of the emotions as a disturbing factor in reading may be illustrated by one introspection where the observer reported that the reading of a certain text put him in a very quiet peaceful mood. This type of mood was correlated with a slight slowing up in the reading time.

The important bodily conditions that had to do with disturbances in reading resulting in lengthened times were, in the main, temporary ocular troubles and disturbances of the vocal mechanism. Various reports brought out the facts of burning and watering of the eyes and occasional temporary loss of focus while reading. Disturbances of vocal mechanism were shown at various times in slight stuttering or stammering. These entered into the inter-

pretation of results in the same way as the foregoing factors.

Mistakes are not mentioned here at length for, in general, they were the concomitants or outgrowths of the three disturbing factors enumerated. In nearly every case, a prolonged reading-time was accompanied by an unusual number of mistakes. Thus we see that there is a high correlation between extremely long reading times and various disturbing factors both objective and mental. In these ways, extreme variations for isolated individual reading-times are accounted for and the resulting curves made more regular.

The uniformity of mean variations as shown on the graphs denotes the uniformity of variation for each leading at a given distance. This gives a high value to the curve as an index to legibility judged by the criterion of reading-time.

On comparing curve III with curves I and II. we see that it shows less strikingly than I and II do, the relation between leading and legibility.

In this connection we must remember, however, that curve III represents only about a third the number of readings that enter into each of the others. Besides this fact, the reduced size must also be taken into account.

An examination of the reading times for the two series given by each observer at a given distance shows considerable practise effect.[6]

[6] These are two like successive series that were combined to form the graphs representing all the readings made by each observer at a given distance.

The cards of the second series were in all cases read more rapidly. This was due in part to practise in reading under such difficult conditions, and in part, also, to the slight familiarity gained by the first reading. However, the factor of familiarity with texts, as brought out by the observers' reports, is perhaps quite insignificant since the difficulty in reading conditions makes it probable that familiarity was masked by the constant effort displayed in the endeavor to read the texts correctly.

Fatigue as a factor in our results may be entirely neglected for at each presentation-period the total number of cards presented was never large.

The graphs I, II, and III, comprising the final results also show a greater dependence of legibility upon leading as the conditions for reading become poorer. It is important to note, too, that leading "7" as judged by our criterion, reading-time, is the optimal spacing for legibility under all the conditions of distance used in our experiments. Another fact that comes out is the gradual increase in ease of legibility with increased interlinear spacing up to the optimal point as set over against the rapid decrease in ease of legibility with increased spacing beyond the optimal point. However, our minimal interlinear spacings denote, in general, higher reading-times than do our maximal spacings.

From an examination of eight books chosen from the general field of literature, eight popular magazines and eight of the leading newspapers of the country, the various ratios between size of type-faces and interlinear spacings in current use

were obtained. It was found by comparing these with the like ratios of our optimally leaded texts, that, in general, current ratios showed a slightly larger type in proportion to the spacing, i.e., the interlinear spacings in common use to-day are probably not wide enough for optimal legibility. Among the books, the spacings were found to accord more closely than among newspapers and magazines with the results of this experiment. Too much emphasis should not be placed, however, upon the poor legibility of the printed page as found in common use to-day for the current ratios fall, as a rule, upon the descending limit of the curves brought out in our experiments.

The value of further experiments using meaningless materials as a check upon this investigation may be here suggested. This material would eliminate to a great degree the disturbing subjective factors which our problem has to take into account. Work should also be done toward the application of our fixed optimal ratio of leading to type-face size in the field of printing at large.

III. Conclusions.

1. The legibility of the printed page is noticeably dependent upon the leading or the space which the printer leaves between successive lines. Up to a certain point, increase of leading improves the legibility of the page; but beyond this point further increase brings about a decline in the rate of reading.
2. There is a spacing between lines which indicates optimal legibility. This may be expressed in the form of a ratio between size of type-face and width of interlinear spacing.
3. Very closely spaced lines are not as legible as very widely spaced lines.
4. There is need in the current field of printing for a modification of interlinear spacing in order to secure increased legibility and ease in reading.